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The Effect Of Cavitation On Adult, Infant and Bovine Articular Cartilage: A Quantitative Study

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Introduction: The term cavitation describes the formation, growth and collapse of gas or vapour bubbles within a liquid. Gaseous cavitation is usually harmless since gas bubbles, for example in carbonated drinks, are relatively stable. Vaporous cavitation, however, is extremely destructive. This is because bubbles of vapour, when created in a liquid by large drops in pressure, are inherently unstable. The drop in pressure can occur anywhere in a liquid system by suction, flow or turbulent vortices. When vapour bubbles created in this way encounter a region of higher pressure they collapse or implode with extremely damaging consequences for solid boundaries nearby. The collapsing vapour bubbles, usually less than 1 mm in diameter, create tiny micro-jets of liquid which can travel at several hundred metres per second. When these jets strike a solid surface they chip it causing pits and craters. Even materials such as titanium, tool steel and concrete can be completely eroded when exposed to cavitation. Our hypothesis is that, since synovial joints are fluid systems which are subject to large cyclic pressure variations during daily activity, microbubbles present in the synovial fluid would grow and collapse cyclically with the pressure variations. During collapse they would create lesions in the articular cartilage surface which would become focal points for stress damage. This has then created a pathway for articular cartilage degeneration.

Experimental Method: Eleven specimens of adult, six specimens of infant and six specimens of bovine condylar articular cartilage were obtained at necropsy. Control specimens were cut from adjacent sites in each case. The specimens, each with a surface area of 10 mm^2 together with 10 mm of subchondral bone, were placed in a saline bath and their surfaces were exposed to ultrasonically-generated cavitation for 1,3 or 5 minutes. After experimentation the specimens and controls were fixed in 2.5% glutaraldehyde for 10 days and then prepared for scanning electron microscopy using a minimal artefact regime. Specimens were scanned on a Jeol SM35CF electron microscope. Damage features on the surface images were analysed for spatial frequency, area and form factor (short axis/long axis) using a Leitz TAS computer system.

Results: The results showed that articular cartilage was vulnerable to cavitation damage, with distinctive cratering being formed through the bursting of surface lacunae. In the human mature material correlations were found between the number of surface features versus exposure time and versus age. Bovine cartilage was found to give similar results to mature adult cartilage whereas infant human cartilage was significantly different.

Conclusion: Cavitation within human joints has a definite potential for the creation of surface lesions in articular cartilage and therefore could be a new aetiological agent in osteoarthritis.

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